

Range & Stopping Power in Nucleonica

CASE STUDY

Q1: What must be the minimum thickness of a shield made of (a) Plexiglas and (b) aluminum in order that no beta rays from a ^{90}Sr source pass through?

SOLUTION:

Firstly, we must know the decay chain for ^{90}Sr .

Go, Applications>Decay Engine

The screenshot displays the Nucleonica Decay Engine software interface. The top menu bar includes 'Applications', 'My Preferences', 'Print', and 'Help'. The main window is titled 'Decay Engine' and shows '38 Strontium' with a half-life of '28.81 y'. Below this, the 'Element' is set to 'Sr' and 'Mass' to '90'. The 'Nuclide Mixtures Selector' is visible. The 'Decay Engine' tab is active, showing input fields for 'Quantity' (Grams, 1), 'Time' (Years, 2.88E+02), 'Accuracy Factor' (1E-02), and 'Number of timesteps' (10). The 'Start' button is circled in red. The 'Type of graph' is set to 'Numbers'. Below the input fields, a table shows the decay chain:

Parent+Daughters	Decay	A(Bq)
38 Sr90	β-	5.00E
39 Y90	β-	5.00E
40 Zr90 Stable		0
Total:		1.00E+10

The 'Download' button is at the bottom left, and the 'Separator' is set to 'Semicolon (",")'. The 'Use field qualifier' checkbox is checked. The Nucleonica logo is in the bottom right corner.

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2

What is the energies of beta rays from ^{90}Sr and ^{90}Y ?
Go Applications>Nuclide Datasheet

Applications My Preferences Print Help

Reference Data
39 Yttrium
Actual Chart: Standard

Element: Mass:
Y 90


Datasheet Description Derived Data Average Cross Sections Radiations Prompt Gamma Select Print Outputs

» Reference Data Notes

Density	4.47 g/cm ³		
Mass Excess	-86487.462 (± 2552) keV		
Atomic Mass	89.907151886 (± 2739) u		
Half-life	2.671 (± 3) d		
Spin	2 ħ		
Parity	-		
Binding Energy	8.69327 MeV/nucleon		
Abundance	-		
Effective Dose Coefficient Inhalation	1.5E-09 (Sv/Bq)		
Effective Dose Coefficient Ingestion	2.7E-09 (Sv/Bq)		
Mean Decay Energies			
Alpha	0 (MeV)		
Electron	933.815 (keV)		
Photon	0.00123656 (keV)		
Type of decay	Branching Ratio	Decay Energy, Q	Daughters
β-	1	2.2801 (MeV)	40 Zr 90

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Applications My Preferences Print Help



Range & Stopping Power

Input Details Compound Details Options

Input Projectile Ion Details

Projectile

Projectile ion: electron

Energy (MeV): 2.28

Target

Aluminum

Density (g/cm³): 2.702

☒ Mono-element ☒ Solid

☐ Predefined compound ☐ Gas

☐ User defined compound

Run

Results

CSDA Range, R: 5.094E-1 cm

Mass thickness: 1.376E+0 g/cm²

Stopping Power (total): 1.549E+0 keV/(mg/cm²)

Table Graph SP Graph Range

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Applications My Preferences Print Help

Range & Stopping Power

Input Details Compound Details Options

Input [Projectile Ion Details](#)

Projectile

Projectile Ion: electron

Energy (MeV): 2.28

Target

Target: Plexiglass

Density (g/cm³): 1.17

☐ Mono-element ☒ Solid

☒ Predefined compound ☐ Gas

☐ User defined compound

Run

Results

CSDA Range, R: 1.249E+0 cm

Mass thickness: 1.462E+0 g/cm²

Stopping Power (total): 1.470E+0 keV/(mg/cm²)

Table Graph SP Graph Range

Range & Stopping Power in Nucleonica

Q2: What thickness of aluminum foil is required to stop the alpha particles from ^{210}Po ?

Hint: Check the decay chain of ^{210}Po , then find the maximum energy of the alpha particles emitted in the chain.

SOLUTION:

Applications My Preferences Print Help

Po210
1.4E2 d

Decay Engine
84 Polonium
Actual Chart: Standard

Element: Mass:
Po 210 Nuclide Mixtures Selector

Decay Engine Options

Quantity: Grams 1 Accuracy Factor: 1E-02
Time: Years 3.81E+00 Number of timesteps: 10 Number of chains: 1

Start Start in background Reset Show details

Parent-Daughters	Decay	A(Bq)	A.beta(Bq)	Is Power (W), $\alpha+\beta$
84 Po210	α	1.57E+11	0	1.36E-01
82 Pb206 Stable		0	0	0
Total:		1.57E+11	0	1.36E-01

No, Radioactive daughter

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6

Applications>Nuclide Datasheet

[Applications](#) [My Preferences](#) [Print](#) [Help](#)

Po210
1.4E2 d

Reference Data
84 Polonium
Actual Chart: Standard

Element: Mass:
Po 210

Datasheet

Description

Derived Data

Average Cross Sections

Radiations

Prompt Gamma


Select Print Outputs

[» Reference Data Notes](#)

Density	9.20 g/cm ³		
Mass Excess	-15953.071 (± 1242) keV		
Atomic Mass	209.982873673 (± 1333) u		
Half-life	138.388 (± 4) d		
Spin	0 ħ		
Parity	+		
Binding Energy	7.83435 MeV/nucleon		
Abundance	-		
Effective Dose Coefficient Inhalation	4.3E-06 (Sv/Bq)		
Effective Dose Coefficient Ingestion	1.2E-06 (Sv/Bq)		
Mean Decay Energies			
Alpha	5.40752 (MeV)		
Electron	9.32726E-05 (keV)		
Photon	0.00972462 (keV)		
Type of decay	Branching Ratio	Decay Energy,0	Daughters
α	1	5.40745 (MeV)	82 Pb 206

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Applications My Preferences Print Help



Range & Stopping Power

InputDetailsCompound DetailsOptions

Input

Projectile

Projectile Ionalpha

Energy (MeV)5.4

Target

Aluminum

Density (g/cm³)2.702

☒ Mono-element

☐ Predefined compound

☐ User defined compound

☒ Solid

☐ Gas

Run

Results

Projected range, R:2.391E+1 μm

Mass thickness:6.460E+3 g/cm²

Stopping Power (total):5.760E+2 keV/(mg/cm²)

TableGraph SPGraph Range

Range & Stopping Power in Nucleonica

Q3: What are the ranges and stopping powers in SiO₂ samples?

n depth

Applications My Preferences Print Help



Range & Stopping Power

Input Details Compound Details Options

Compound composition

User defined compound SiO2

Z Element Atomic Weight
8 Oxygen 15.999

Add Remove Remove All

	Z	Element	Atomic Weight	Stoichiometry
Edit	8	Oxygen	15.999	2
Edit	14	Silicon	28.086	1

=====
Calculation using SRIM-2006
SRIM version --->
Calc. date ---> Oktober 02, 2008
=====

Disk File Name = range_out2.txt

Ion = Carbon [6] , Mass = 12 amu

Density = 1.0000E+00 g/cm3 = 3.0068E+22 atoms/cm3

=====
Target Composition =====

Atom Name	Atom Num	Atomic Percent	Mass Percent
O	8	066.67	053.26
Si	14	033.33	046.74

=====
Bragg Correction = 0.00%

Stopping Units = keV/(mg/cm2)

See bottom of Table for other Stopping units

Ion = Carbon [6] , Mass = 12 amu

Ion Energy	dE/dx Elec.	dE/dx Nuclear	Projected Range	Longitudinal Straggling	Lateral Straggling
999.999 eV	1.153E+02	5.618E+02	106 A	73 A	53 A
1.10 keV	1.209E+02	5.701E+02	114 A	78 A	57 A
1.20 keV	1.263E+02	5.772E+02	122 A	83 A	60 A
1.30 keV	1.314E+02	5.833E+02	130 A	87 A	63 A
1.40 keV	1.364E+02	5.885E+02	137 A	92 A	67 A
1.50 keV	1.412E+02	5.930E+02	145 A	96 A	70 A
1.60 keV	1.458E+02	5.970E+02	153 A	101 A	73 A
1.70 keV	1.503E+02	6.004E+02	160 A	105 A	76 A
1.80 keV	1.546E+02	6.033E+02	168 A	109 A	79 A
2.00 keV	1.630E+02	6.080E+02	183 A	118 A	85 A
2.25 keV	1.729E+02	6.122E+02	201 A	128 A	93 A
...
150.00 MeV	1.136E+03	5.492E-01	771.98 um	29.13 um	8.35 um
160.00 MeV	1.076E+03	5.183E-01	862.38 um	31.87 um	9.24 um
170.00 MeV	1.023E+03	4.908E-01	957.64 um	34.67 um	10.17 um
180.00 MeV	9.750E+02	4.663E-01	1.06 mm	37.51 um	11.15 um
200.00 MeV	8.918E+02	4.241E-01	1.27 mm	48.37 um	13.24 um
225.00 MeV	8.070E+02	3.814E-01	1.57 mm	64.02 um	16.11 um
250.00 MeV	7.384E+02	3.469E-01	1.89 mm	78.89 um	19.26 um
...
800.00 MeV	2.934E+02	1.207E-01	15.21 mm	660.40 um	145.03 um
900.00 MeV	2.679E+02	1.084E-01	18.78 mm	832.40 um	177.97 um
1.00 GeV	2.472E+02	9.848E-02	22.67 mm	998.94 um	213.62 um

Multiply Stopping by for Stopping Units

9.9997E-03	eV/Angstrom
9.9997E-02	keV/micron
9.9997E-02	MeV/mm
1.0000E-03	keV/(ug/cm2)
1.0000E-03	MeV/(mg/cm2)
1.0000E+00	keV/(mg/cm2)
3.3257E-02	eV/(1E15 atoms/cm2)
4.9275E-04	L.S.S. reduced units

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Not Important

Thanks!



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